

McBee cards from Enderbury. Not checked against collected specimens. List made by Church

algae - listed as 2364, 2365 and 2663. 2663 is probably 2363. Long #s
Digitaria pacifica Stopf. Long 2107, 2680.
Eragrostis whitneyi Fosberg var. *Whitneyi*. Long 2090, 2108, 2111, 2656, 2661, 2668, 2677, 2683. PW 1-7.
Lepturus repens (Forst) R. Br. Long 2092, 2104, 2109, 2115, 2118, 2649, 2654
Fleurya ruderalis Gaud. Bryan 29. Long 2117
Boerhavia tetrandra Forst. Bryan 32, Lamb (1938) ~~xxxx~~s.n.,
B. species; Long 2094, 2096, 2102, 2119-2121, 2651, 2666.
Sesuvium portulacastrum L. var. *griseum* Deg. & Fosb. Lamb (year 1938), s.d. Long 2097. 2112, 2653.
Portulaca lutea Sol. Lamb s.n., Long 2613, 2667, 2686.
Cassytha filiformis L. Long 2682, 2106.
Euphorbia hirta Linn. Bryan 20.
Triumfetta procumbens Forst. Lamb s.n.; Bryan 1334; Long 2103, 2105, 2113, 2116, 2652, 2684, 2685.
Sida fallax Walp. Long 2098, 2650, 2670.
Ipomoea grandiflora (Choisy) Hollier (marked probably tuba beneath). Bryan 31, Lamb s.n., Bryan 1333
Ipomoea sp. Long 2099, 2655, 2678
Cordia subcordata Lam. Lamb s.n., Bryan 1336, Long 20912093, 2100, 2662
Messerschmidtia argentea (L) Johnston, Lamb s.n., Long 2095, 2681.

no need to
return this copy.

July 11-17 Enderbury Island - Summary

(Taken from notes by Peter Marshall).

The plant covering at Enderbury is much more interesting than Howland and Baker because the size of the island allows several different conditions to exist, with the same basic plants compensating to adjust to there different surroundings. A good example of this is plant No. 13 which grows in each of the three environments (a. guano sand soil near camp, b. salt soaked guano of the lagoon, c. barren piles of rock and reef). In the pressing of this sample, I show two of the forms, the normal and the dry. (Left out is the bush growth of the interior.)

Plant No. 1 - Tournefolia. Two clumps of tress on the island, one (north of camp) very large and supporting a large colony of greater frigates and one near the south east which is much smaller. The growth seems to now be checked by the birds, which leads one to believe that they grew up to their large size when there were much fewer birds.

All the upper branches of these small trees (8 - 20 feet) are now dead and the only growth occurs at the bottom.

Plant No. 2 - Sesuvium. Litterally covers and blankets the inner part of the island. Small white flowers.

Plant No. 3. - Leaves in line type succulent. Common along outer 200 feet of island. Very adaptive to good and bad conditions.

Plant No. 4 - Parantic? - This tenticle plant appears to have no roots, and does have small suction cups where it engages other plants. Exists only in one place (just east of old stove runs) where it covers everything in sight with a tangle-blanket of stems. There appears to be small leaves at the end of each stem.

Plant No. 5 - Succulent. Same distribution as No. 3. Orange flowers.

Plant No. 6 - Wide blade grass, many dead plants on inner part of island living ones same distribution as No. 3.

July 11 - 17 Enderbury Island - Summary

Plant No. 7 - Narrow blade grass. In bunches between stone river and guano hill.

Plant No. 8 - Type of morning glory? Has orange flowers whirl yield dots of stickers and burrs all over beach. Found all around islands.

Plant No. 9 - Same as No. 7 from Baker. Distribution as for No. 3

grows vertically and horizontally. Reaches height of 2 feet.

Plant No. 10 - Kou Tree - Two groups one near guano hill, one south end of island. Red-footed Boobies nest and roost in there. There trees have also been severely damaged by the birds.

Plant No. 11 - Unknown plant. Only two found on whole island. May be the sapling of the Trounevolia. Found just east of stone ruins.

Plant No. 12 - Morning glory. Large white flowers. One plant may cover a whole ravine. There grow only in the little ravines cut into the outer circle of the island from the lagoon.

Plant No. 13 - Crawling plant. Small white flowers. Grows every where as in No. 3, plus the coral mounds at the north and central parts of the island.

Plant No. 14 - Palm tree. Extinct. There was once three groups of the, but these have been completely wiped out by some unknown force, and have never grown back. There are many nuts surrounding where they grew.

In the northern and eastern parts of the island there are numerous valleys which are completed with plants.

C.R. Long
1964

Enderbury Island

July 15, 1964 - A landing was made about 1:30 pm. Camp was set up in shed and shack. I walked the west shore of the island - very rocky and the vegetation is not as lush as at Phoenix - at least on this southwest end. Tropic birds observed nesting under slanting stone slabs. rocky with patches of sand and gravel sand

* Transect I	<u>Digitaria</u> <u>Triumfetta</u>	→	<u>Portulaca</u> <u>Triumfetta</u> <u>Digitaria</u>	→	<u>Sida</u> <u>Portulaca</u> <u>Boerhaavia</u> <u>Digitaria</u>	→	<u>Sida</u> <u>Portulaca</u> <u>Boerhaavia</u>	→
	sand and gravel		slope				darker soil	
	<u>Boerhaavia</u>		<u>Digitaria</u>		<u>Lepturus</u>		<u>Boerhaavia</u>	<u>Sida</u> →
	<u>Portulaca</u> →		<u>Lepturus</u>	→	<u>Boerhaavia</u> →		<u>Portulaca</u>	→ <u>Lepturus</u>
	<u>Lepturus</u>		<u>Portulaca</u>		<u>Triumfetta</u>			<u>Sesuvium</u>
			<u>Boerhaavia</u>		<u>Portulaca</u>			
	<u>Sesuvium</u> →			→	<u>Sesuvium</u> <u>Eragrostis</u>			
	edge of lagoon				raised islet			
	salt crust				guano soil with much shell material			

Observed

Boerhaavia sp. with white flowers and little or no anthocyanin in the exposed stems. Messerschmidtia argentea (L.f.) Johnston comprises the brush area as on the chart. This shrub sprouts on the bottom branches and has flowers, the upper parts appear dead possibly as a result of the high concentration of nesting lesser frigatebirds (guano concentration on live stems and leaves, and physical damage as a result of nest building and other avian activities) and/or the high insolation and continuous drying wind. Red footed boobies are also found nesting in this "brush".

On the east side of the lagoon - along the edge - were observed several dead patches of Sesuvium sp. indicating perhaps an earlier high water in the lagoon. Evaporation must be rapid but not always so rapid as to insure that even Sesuvium (which has been observed living submerged in salty water) will not be killed back. Sesuvium forms an uneven cover over guano or gravel surfaces associated with Lepturus, Portulaca and Sida - at the periphery of the lagoon, on raised dry heads covered with guano and in the areas just above or in back of the lagoon edge. On this island the Sesuvium forms no solid mat (uninterrupted). Counted twenty-four golden plovers.

July 16, 1964 - Plant presses taken out to ship. Dry plants taken from the presses. Drying conditions in the engine room are not ideal. The humidity is too high. The best action is to take smaller samples and segregate the succulent material. On next trip will either have a portable drier or saturate the material with paraformaldehyde solution and defer drying until we reach Honolulu. This latter method might also make for a more organized procedure on shipboard - avoiding the mess and heat of the engine room.

Into the field at 3:30 pm walking north toward the lagoon and then on to the north end of the island - mapping vegetation and placing permanent markers (steel poles). North of the old guano ruins a large colony of nesting Greater Frigates - in dead or weakly sprouting Messerschmidtia (some Cordia sp. also present). At the edges of the colony some of the birds make their nest on

C.R. Long
1964

shrubby Sida bushes. The nests are constructed of Sida twigs with Boerhaavia stems and leaves placed in the center. The nests in the dead or weakly sprouting Cordia and Messerschmidtia are composed of Sida twigs piled high. The twigs on the bottom are weathered a gray color while those on top are lighter and appear to have been added at a later time. The Digitaria sp. is much shorter and less vigorous in appearance than that observed on Starbuck. Much of the Sida is prostrate - only at the protected edges of the lagoon or around the outside edge of the brush patches is the Sida upright. Both seedling and adult plants of Sida seem to be frequent in the Sesuvium patches rimming the lagoon (on the north end the Sesuvium has filled in the old lagoon area). The wind seems to be out of the east at this season and almost constant. The brush piles, located toward the rim of the islands must also penetrate deeper for moisture to the fresh water lens below. This lens is subject to greater depletion in the dry lagoon areas and perhaps the lens is contracted during periods of extreme evaporation and dryness. The guano soils and underlying hardpan, and, the salty crusts formed in the lagoon beds may be responsible for the existence of any vegetation available water supplies on these dry islands. The Lesser Frigates nesting in the brush patch "spill over" into open areas on the west side (bare surfaces or some small Sida and Lepturus). Further along this side of the island is a guano mound, guano operation ruins and another brush area with Cordia and Messerschmidtia spp. supporting the nests of Greater Frigatebirds and redfooted boobies.

Transect II (starting on the west near old guano diggings - from the shore).

<u>sand</u>		<u>gravel and sand, bare disturbed site</u>	
<u>Triumfetta</u>	→	<u>Sida</u>	→ <u>Boerhaavia</u>
<u>Digitaria</u>		<u>Lepturus</u>	dead <u>Cordia</u>
		<u>Portulaca</u>	
		<u>Cassytha</u> on <u>Sida</u>	
<u>larger gravel, rocks</u>	→	<u>former house sites</u>	<u>mid-point of island</u>
<u>Lepturus</u>		<u>gravel and sand</u>	
<u>Sida</u>		<u>Digitaria</u>	<u>Sida</u>
<u>Portulaca</u>			<u>Portulaca</u>
			<u>Boerhaavia</u>

In the rubble of the old guano operations on the north end of the island the Sida - Portulaca - Boerhaavia association was observed. A few clumps of Lepturus are also present but very sparsely distributed in this area. The distribution of plant species on the north end is non-uniform. On the rocky flats and rolling mounds Boerhaavia is found - suggesting, perhaps, a pioneer species in rocky or heavily gravelled areas. In some of these same areas one finds Portulaca associated with the Boerhaavia. It may be that the perennial Boerhaavia with its seasonal addition of dead leaves and stems and, finally, a dead rootstock of considerable size may contribute significantly to the windblown sand (which accumulates between and down below the rocks) - and windblown organic matter to form the necessary soil pockets for the successful sprouting and growing of other species. The Portulaca is shallow rooted and needs a soil which will hold some water content and at the same time be near the sunlit surfaces. In semi-protected areas behind the hillocks you find patches of Lepturus, usually on the east face slopes. In the depressions between the hillocks - in coral gravel and guano soil Sesuvium seems to thrive, but not forming a continuous mat over the

surface. Sida and Portulaca are scattered about in mixed clumps or alone. The vegetation here reflects the disturbance of the past. The loss of cover and the making of new substrates shows vividly the time required for the vegetation associations of low, dry islands to become established. On the west face of one guano mound Fleurya ruderalis was collected - stems very succulent. The plants are shallow rooted. Perhaps during heavy rain the guano soils absorb a large amount of the rainfall and/or the depressions are filled. This latter source of water would supply moisture to the sides of the guano piles.

Permanent markers - No. 1 - placed in coral gravel ridge north of the larger guano pit. The cover in this area is approx. fifty percent with Sida, Portulaca and Boerhaavia associated. The site is nnw of the Enderbury light. In the areas between the rubble piles on the west end there are good stands of the Portulaca - Boerhaavia association. These areas have gravel on top with a mixture of sand and guano below forming a fine soil. The best stands are in spots with some protection from the prevailing wind.

Permanent marker - No. 2 - placed in fine coral gravel between small rubble mounds - about one-half mile due north and slightly east of the large guano mound on the west side of the island. Here is found a Portulaca-Boerhaavia association. Four golden plovers observed on the ground in this area. On the north side near the beach are a series of deep gouges - approx. ten to twenty-five feet deep. Guano is found on the bottom with small plants of Sesuvium and some Sida seedlings. At the north raised end of the deepest gouge are Portulaca and Sida with trailing Triumfetta on the rocky (with sand pockets) sides of the gouge. On the top of the slope on the north end are found Portulaca, Boerhaavia, Sida and some scattered clumps of Lepturus. On top near the beach one finds Triumfetta alone. This area particularly in the distribution of Portulaca and Lepturus reflects the importance of substrate and topography in the distribution of species on low dry islands. I walked along the north beach to the east end and found Triumfetta, Boerhaavia, Lepturus and Sida - cover is very sparse. I suspect Portulaca also present but there was little light left.

* see vegetation map of Enderbury Island constructed by C.R. Long from observations and field notes taken between July 15-17, 1964.

sand. The stems of Triumfetta are to 10 m. in length with upright sprouts. Not common, probably a wave carried adventive.

Found along the west side with Lepturus and Digitaria, less apparent elsewhere

At the edge of hardpan just above the lagoon flat on the midwest side. Also occurs at the bottom of a shallow depression N of the guano workings. Not common on Enderbury but commonly ^{well} distributed in the Phoenix and Line islands.

Small trees occur in restricted groves on the S and W sides often with Tournefortia. Used as nesting sites by the redfooted booby and greater frigatebird.

Small trees found on the W and S sides with Cordia used as nest sites by the species cited above. Much of the groves on the W side are composed of dead wood. Heavy concentrations of nesting birds combined with salt spray (especially with Cordia) restricts growth. Green sprouts in the area of nest platforms were torn and guano covered. Accumulations of guano found at the surface under these groves but no evidence of phosphatization such as occurs on wet islands under Pisonia was observed.

Fifteen species of vascular plants have been recorded from Enderbury Island. Ten of these are considered native, two are problematical introductions and ~~three~~ are known introductions since the European discovery of the island. Only Digitaria of the introduced plants appears to have naturalized to any extent.

Collections of vascular plants from Enderbury Island have been made by the following: E. H. Bryan, Jr., March 1924 and July 1938; S. H. Lamb, ~~1938~~ March 1938; C. R. Long, November 1964; P. Woodward, February 1965. July and

we found a quantity of driftwood, lying just on the edge of the bank of coral slabs. Some of the trunks were very large, being fifty or sixty feet in length, and from two to three feet in diameter. — The locality in which these large trees are found, would show that there is at times a very great rise of the waters, which must submerge the islands altogether." This account was botanically accurate and gives much valuable data with which to make comparisons. In 1964 the channel mentioned by Wilkes was no longer evident represented by a narrow area on the NE side behind which there occurs a low lagoon flat covered with Sesuvium, Portulaca and Eragrostis. In the latter half of the nineteenth century guano mining was carried out on Enderbury Island. According to Hutchinson (1950) about 100,000 tons were removed chiefly from the northern portion. Much of the low flat area around the lagoon and ^{now} covered with stands of Sesuvium — Eragrostis were also mined probably lowering the soil level to hardpan. During the 1930's colonists were established on the island by the U. S. Department of the Interior. Attempted plant introductions were not successful. The estimated amount of guano taken from Enderbury Island does not seem compatible with the present numbers of nesting sea birds. The guano areas of the island are at the edge of a lagoon which has probably dried up, or, at least been closed off in the recent times. The discovery of recently deposited marine mollusks supports this contention. The bluefaced booby is the chief nester along the lagoon rim but the present population would need a very long period with maximum populations in order to deposit 30 cm. of guano (Hutchinson, 1950). It seems necessary to suppose a possible shift in waters of high productivity near Enderbury and a drop in the population of guano depositing bird populations. The other alternative is to suggest a shift in rainfall patterns and a subsequent dying out of a Pisonia type vegetation under which guano deposition seems to occur on many of the wet islands (Fosberg, 1957). No remnant population of Pisonia occurs on Enderbury Island but a comparably dry island (Malden) does have a few Pisonia which are adjacent to the large guano works on that island. Oceanographic research in the Phoenix Islands may help favor one or the other of the above suppositions. It seems highly probable that the genera Sula and Fregata were and are responsible for the deposition of guano soils on dry central Pacific atolls. The Tournefortia grove on the west side of the island supports nesting populations of Sula sula and Fregata minor. There was no evidence of a phosphatized layer forming underneath the thin litter layer. It is these species with Sula dactylatra and Fregata ariel which deposits layers of guano in open sites where accumulation is apparent on the basis of the individual organism. The influence of man has been relatively slight on Enderbury Island as regards the vegetation. The thick guano layers, however, point to a period in the natural development of the island when the vegetation may have been of a differing composition or to a change in the numbers of nesting seabirds on Enderbury Island. (Digitaria pacifica has naturalized over the sandy inner slopes of the island and appears to be colonizing such areas.)

The guano layers originally mined on Enderbury may have been laid down under climatic and/or vegetation regimes which are no longer extant.

3 Fosberg, F. R. Atoll Vegetation and Salinity.
1949. Pacific Science 3 (1): 89-92.

2 Dawson, E. Y.

1959. Change in Palmyra Atoll and Its Vegetation
Through the Activities of Man, 1913-1958.
Pacific Naturalist 15(2): 1-51.

1 Bryon, E. A., Jr.

1942. American Polynesians and the Hawaiian
Chain. 1-253. Honolulu.

3 Wilkes, C.

1845. Narrative of the United States Exploring
Expedition, vol. 371. 1838-1842.
Philadelphia.

4 Hutchinson, G. E.

1950. The Biochemistry of vertebrate evolution.
Am. Mus. Nat. Hist. Bull. 96: 1-554.

5 Sacket, M. H.

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249-307.

The vegetation of Enderbury Island is typical of the very dry atoll flora found in the central Pacific. Among the native plants are found Eragrostis whitneyi and Sesuvium portulacastrum var. griseum both of which are taxa endemic to low island atolls of the Pacific. Both of these species and Lepturus repens, the common bunchgrass, cover large areas on the inner flats, ~~or~~ slopes and beach crest. The Lepturus is found commonly in the sandy peripheral regions and inner slopes while the Eragrostis is confined to low guano emptied areas on the NE, S and on the drier portions or elevated "islets" of the large central lagoon. Many such sites support tall clumps of this small grass but more often the clumps are very short. This probably results from periodic inundation of low areas in the central portion of the island during occasional heavy rain or high tides. Eragrostis apparently cannot stand inundation as can Sesuvium with which it is often associated. The introduced Digitaria pacifica is scattered along the inner slopes ~~along~~^{of} the west side. First collected by Marshall in 1964 it may have been introduced as early as the ^{days of guano mining.} mining of guano.

Other native herbs such as Portulaca lutea, Boerhavia repens, Triumfetta procumbens, Cordia subcordata, Tournefortia argentea, Cassytha filiformis and Sida fallax are common ^{vegetated} although only the first two are abundant and found over most of the area of the island. The Triumfetta is restricted to sandy slopes on the NW side. The shrubby Tournefortia and Cordia form small groves, mixed and pure on the W and S sides, ^{both are deciduous during dry periods} Sesuvium is common along the edges of the lagoon and in open flats, areas where guano soils have been removed and the elevation of the soils decreased so that the ~~under~~ subsurface soils are constantly moist - often with ^{overlapping coralline} ~~hardpan~~ ^{hardpan} Eragrostis. This succulent plant ^{variety} is apparently one of the few known endemic plants found on coral atolls. Cassytha was found on the west side of the island parasitizing Sida and Portulaca lutea. Among the introduced plants Euphorbia hirta was ^{formerly} found near ^{guano pile} the wooden structure on the SW side. Fleurya ruderalis and Ipomoea tuba are rare. The former was growing on a pile of guano soil near the old guano workings and the latter at the edge of the lagoon on coralline hardpan. The climate or restricted holding capacity of the fresh water lense probably accounts for the failure of Cocos, the remains of a number of which were found in three depressions on the N and S sides of the island, areas left apparently between deposition of coral rubble by high wave action.

The major demarcation^s in the vegetation zones of the dry islands occur^{along} is found at the elevation of the lagoon and proceeds to the top of the inner slopes. Under natural conditions the lagoon basin is at sea level or just above - thus some of the lagoons of the dry islands have more seepage than others due to the tidal fluctuations and fill found in the lagoon. Some of the islands have lagoons which were filled in above the level of the sea. Normally around the edges of the lagoon is a low flat, often submerged area on which the halophytic Sesuvium forms luxuriant mats. Not more than a half meter above this area one finds a transition to a Portulaca - Lepturus association found in some cases on guano soils adjacent to the lagoon. On the slopes above with more depth of soil other herbaceous plants such as Boerhavia and Sida form an association. Lepturus is usually found in thick often pure stands on the outermost beaches and not uncommonly on the inner most edge of the lagoon near seeps. In the case of Enderbury Island this concentric ring of species and species associations seems to hold true except in areas where the substrate becomes a limiting factor. Sesuvium, for example, is not found on sand beaches except in areas where the sand is underlain by a watered hardpan. An area a few m^2 exists on the NE side of Enderbury in the area where an opening to the sea was reported by Wilkes (?). On Enderbury the importance of sandy areas left in the midst of high waverows of coral rubble is evident. The groves of Cordia and Tournefortia on the south end and the former Cocos pits on both the north and south ends are such areas. Such areas apparently marked the an area of seepage connected with the lens and were surrounded with piles of coral rubble. In such sites are also found vigorous Sida, Ipomoea tibia and, in such areas with sandy sides, Triumfetta.

A number of surface soil samples were taken and will be reported on elsewhere. The soils found on the island are typically sand based with additions of varying amounts of organic material of two types, bird guano and decayed vegetable material much of which is processed by the hermit crabs. Much of the inner slopes - the wider found on the west side - are covered to a depth of several dm. with a sandy soil ~~overlying~~ which overlays wave deposited coral rubble. Many areas on the N and S sides which are more recent deposits judging from the lack of soil cover have pockets of sand but these are often too far from the surface to provide a habitat for plants. In other areas coral waverows have been filled with wind and wave deposited sand and on which pioneer plant species such as Boerhavia and Portulaca find a niche. Often these waverows become obscured by the deposition of sand and the formation of soil subsequent to the formation of plant communities. The soils range from almost pure sand to those which contain a low degree of organic material. In some small sites such as thick stands of Lepturus, under Tournefortia and Cordia groves and in locally more mesic sites with lush vegetation one will find ~~hi~~ correspondingly higher amounts of organic material mixed with the sand. A second type of soil is found in the low, former lagoon flats and present lagoon with its numerous islets. On the flats one finds a reddish brown, friable soil derived from guano accumulations of nesting seabirds. At the dry edges of the present lagoon a highly saline soil also with admixtures of guano is found. On the dry islets a lighter powdery guano soil with an admixture of ~~salts~~ ^{not chlorine} and calcium carbonates derived from exposed fossil layers of mollusks which inhabited the old lagoon, is found. On this soil type are found Sesuvium and Eragrostis and sparingly Portulaca lutea, Sida fallax and Lepturus. At perhaps a half m. elevation ~~away from~~ ^{above} these low guano soil area one finds Portulaca as a common component of partially guano filled soils. It may be that with the lowering of the flats due to the guano mining that the areas for optimal growth of the Sesuvium - Eragrostis association were increased to the detriment of that area on which was found at an elevation only perhaps a half meter higher the Portulaca - Lepturus association which may have characterised much of the guano filled areas of the dry central Pacific atolls.

The concentric pattern of atoll vegetation can be seen on Enderbury

Island. This has been reported to be mainly a result of salinity of the ground water (Fosberg, 1949). One seep at the edge of the present lagoon contained 75.2 ^{parts per thousand} ppm of salts almost double that of sea water. In the case of some of the drier islands ^{with enclosed lagoons} the interior of the island ^{may be affected by} results in an increase in the salinity due to the closed nature of the lagoon and the evaporation of standing sea water seepage from shallow surfaces. ^{may accentuate the importance of salinity and its effect on the vegetation} One possible factor of importance in the salinity gradients ^{found on} of dry islands would be the increase of salinity in the lagoon which goes hand in hand with the closing off of channels. One interesting case is that of Sydney Island a small atoll which has been an enclosed lagoon cut off within historic time much like the one at Enderbury. A sample of water taken from the lagoon water in the vicinity of islets along the NW shore evidenced a salinity of 166.0 ppm, nearly five times that of seawater. This increase in salinity may control to a great extent the species found on the dry islands ^{considering the species found in atoll} working from the lagoon to the outer beach. There is a suggestion that the dying Pisonia on Gardner and Sydney may be due to a combination ^{both} of the lack of rainfall and an increase in the salinity of normally tolerable levels of salinity associated with the lense of freshwater. One of the village wells 2.2 m. deep on Sydney contained brackish water in October 1964. ^{Two taro pits were tested, both were brackish but a seed was growing in one.} If rainfall is negligible and evaporation continues over a long period the fresh water lens may be exhausted in some areas particularly in narrow sides of islets and enclosed islands. Saline waters ^{tend to} would be replacing these at levels where the roots of shrubs and trees penetrate. An unusually high salinity in waters underlying the islets would raise the salinity of the groundwater and may contribute to the irregular pattern of vegetation associations or distribution of species on dry atolls. The Pisonia groves of both Gardner and Sydney Islands are dying or in a state of extreme drought. This is a species usually identified with the more mesic sites of a coral atoll. It is suggested that the increased salinity of lagoon waters due to the enclosure of a once open lagoon may be partly responsible due to the raising of the salinity of the groundwater. This with the prevailing drought may be responsible for the apparent dying back of potential Pisonia groves on these islands.

July 17, 1964

Plot III - Eleusine - Sesuvium bare flat light is W, S.W. - 4 plot. approx. 1/2 mi. from shack. Picture taken - south, east, and north. (9:25 am.) large solid patches of Eleusine alternate in irregular patchwork fashion with Sesuvium. The latter is not level and thick. Plot has to be propped with stones - soils about 6-7 in. deep - hard coral rock beneath.

In bare mid southern portion of island - coral rock is exposed - here one finds Portulaca and Sesuvium. Eleusine confined to sandy grassy earth area. hosting ^{sooty} ^{marked} Towns and gray-backed Towns. Scattered pres. of Boerhaavia on upper slopes of bowl - need slope for take off - wind is best there - in Sesuvium area. Near shack clut of marked boobies in Boerhaavia - Sida - effective tangles of vegetation - grass also probably is detrimental to plants.

On rise to east beach - Boerhaavia, Lepturus and Portulaca - sandy soil, gravelly on top.

South side

Portulaca, Lepturus, Cucumis on first beach.

Sandy soil.

Indepression south end of island: Sesuvium, Lepturus; Sida and Boerhaavia along side. on bare rock ridges - Cucumis, Boerhaavia, Portulaca.

Post IV - south end; between Cordia grove -
shack visible slightly south of west. Post in
large grove - Boerhaavia - Portulaca cover.
Pictures taken.

Post at south end of island has Sesuvium
with Portulaca and Sida. Lepturus along
edges. Towards beach high rock piles.
Lepturus, Sida, Portulaca form
sporadic patches in Sesuvium mat area.
Elaeagnus,

Coll. #s (2021-2024),
topographical features and substrate very
important as shown on south end of island both
in vegetation and bird distribution.

Boerhaavia - some quite lush with new runners
in clumps - old runners dried or in bloom de-
pending on the local moisture conditions.

(Quite tired - Phoenix Is. was tiring and we came
off onto Enderbury immediately after lunch. We
left Enderbury early on July 18, 1964 - to Con-
ton for mail; then on to McKean Is. (just
three small islands remaining to examine). Just
listening to Republican Convention - Goldwater
making evening speech to the Convention. Shocked
at his nomination and support from Nixon, Eisen-
hower and Rockefeller.

Digitaria pacifica much shorter less level than on Starbuck. Much of Sida procumbent - only in protected edges of lagoon or around level is Sida upright. Sida, both seedlings and young plants seem to be frequent in Sesuvium patches rimming lagoon (on north end Sesuvium has filled in old lagoon area).

Cordia - Messerschmidia grows dry on top - dead looking / a combination of a. low rainfall or low ground water; b. constant wind (East to west) across island; c. guano droppings on stems and leaves from nesting lesser frigate and red-footed boobies. Frigate colonies formed about brush patch and into open area (on west side). Only a few frigates and red-foots near guano rich brush pile.

Red-foot nests of Sida in old cordia limb.

Thomast^{II} at old gunn digging west side of slouch

basal
Cucurbit
Digitalis
 caryophyllaceae
 (Sida)

→ Sida
heptanema
Portulaca

→ Berlaque
cardinalis
cordifolius

→ heptanema
Sida
Portulaca

rocks (ground)

→ Digitane → Sida to mid point
in form Portulaca
have ribs Berberis A side

Sida - Boerhaavia - Portulaca - in rubble of old ground
digging north end of island. Some Lepturus but very sparse.
Distribution non-uniform - on rocky flats can find
nothing but Boerhaavia in other Boerhaavia - Portulaca.

Sida patches are occasional along rim of old gum works,
as is a few scattered clumps of hepturus.

In protected area (behind lighthouse) patches of Lepturus on bare coral bottom. Sesuvium (not thick) Sida - Portulaca scattered about mixed or in pure stands (obviously vegetation pattern of disturbed area.)

Amaranthus grows in gravel mounds!

Post I placed in coral gravel behind wall of guano pit. Boerhaavia, Portulaca on side - corner approx 50% - much of area bare. North north-west of lighthouse.

In area between rubble piles on west side good stand Portulaca - Boerhaavia. Soil gravel on top - fine beneath - somewhat protected from wind.

Post II - placed in fine ^{one} gravel bet ween rubble mounds - Portulaca - Boerhaavia - about $\frac{3}{4}$ mi. due north of east end of guano mound.

Saw 4 garden places. last group on north end 20ft deep - guano on bottom - Sesuvium Sida seedlings - some Lepturus on north end. Sida, Portulaca, Cucumis on rocky slopes of group. On north end in sandy gravel - Sida, Portulaca, Lepturus, Boerhaavia.

On top of beach trailing Cucumis alone. In both Lepturus & Portulaca Topographical distribution exemplified. Heading along north beach - Cucumis, Boerhaavia, Lepturus, Sida (all sparse)

on beach

in back

n. east beach

Sesuvium

Cucumis

Portulaca

Sesuvium

Lepturus

north
east side
beach
blown
out

2011-2020 numbers pressed.

2021-2025 (July 17, 1964).

July 15, 1963 - landed at Enderbury at 1:30 pm. Set up camp in shed and shack.

Walked west shore of island, very rocky, vegetation not as lush as on Southwest end as at Phoenix. Tropic birds nesting under slanted faced stone slabs.

Ternet I	Beach	old ruin rocky with gravel & sand rubble		fore sandy gravel	
		Portulaca Cucumis Digitaria a.	Portulaca Cucumis Digitaria b.	Sida Portulaca Boerhaavia Digitaria c.	Sida Portulaca Boerhaavia d.
					Boerhaavia Portulaca Lepturus e.
f.	Digitaria Lepturus Portulaca Boerhaavia	g.	Lepturus Boerhaavia Cucumis Portulaca	h. rocky Boerhaavia Portulaca	i. Sida Lepturus Sesuvium
					j. Sesuvium

→ bare lagoon floor. → island
shells
salty mudlike
mud

Boerhaavia diffusa (wt. fls., green stems).
meneschintha argentea comprises the "bush"
of map - a line on bottom sides - upper parts killed
by high conc. of nesting lesser frigates and red-
footed boobies.
On east side of lagoon edge dead Sesuvium
indicating high water in lagoon and rapid
erosion. Sesuvium forms uneven cover over
gravel or gravel surfaces with Lepturus, Portulaca,
Sida in other areas. Sesuvium form no solid
mat.

24 garden plots sighted

Plants of Enderbury Island

Sida fallax

Cucumis sp.

Portulaca oleracea

Digitaria pruriens

Lepturus repens

Boerhaavia diffusa

Corytha filiformis

Eleusine indica

Sesuvium portulacastrum

Sporaea or Convolvulus sp.

Messerschmidia argentea

Cordia subcordata

Amaranthus

Collecting number: 1990-2010.

Some preliminary mapping done.

July 16, 1964 to ship for supplies. Plant
go out - dry plants taken from press.

Into field 3:30 pm. walking north towards lagoon - on
to north end of island - mapping, placing of stakes.

Large colony of nesting lesser frigate north of
old mine - nesting in dead Cordia - Messer-
Schmidtia

In open - nest on Sida composed of Boerhaavia,
Sida twigs. also nests in dead Cordia of piled
twigs of Sida - Boerhaavia. Platforms apparently
reared and added to (judging from color of
bottom (gray) and top (brown) material).

Enderbury Island

9 November 1964
10 November 1964

north End:

Portulaca lutea

Lepturus repens

Digitaria pacifica

Sesuvium portulacastrum

Ipomoea sp.

Sida (fallax?)

Boerhaavia diffusa

Eragrostis sp.

Triumfetta procumbens

Triumfetta occurs at best growth on sand outer beaches but also does well at lagoon or depression edges (former lagoon areas) in coral gravel and sand. The vegetation is about as dry as last trip. Daily rain laden clouds pass but so far (10th) only a few drops of rain although good squalls have been seen passing south of the island.

The Cordia groves on the s end have flowering shoots and green leaves. The Eragrostis on the islets in the lagoon and in the lagoon flats to the south is quite dry. a few green plants were found in the damp guano soil on the lagoon flat west side late in the day on the 9th. Digitaria and Lepturus are quite dry and brown over the entire island except at well watered lagoon flat depression of s end where this sp. and Sida, Ipomoea and Portulaca are all in bloom.

Enderbury Island
July 15, 16, 17 - 1964

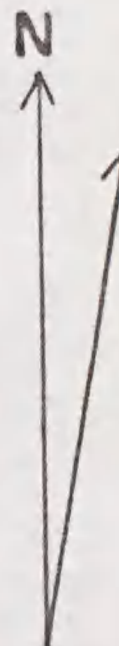
1. Sida fallax Walp.
2. Triumfetta procumbens
3. Portulaca lutea Sol.
4. Digitaria pacifica Stapf.
5. Lepturus repens (Forst.) R.Br.
6. Boerhaavia diffusa (Forst.) R.Br.
7. Cassytha fijiiformis L.
8. Eragrostis ~~sp.~~ whitneyi Forberg
9. Sesuvium portulacastrum L.
10. Ipomoea sp.
11. Messerschmidia argentea (L.f.) Johnston
12. Cordia subcordata Lam.
13. Flemingia sp.



- 1 LEPTURUS - PORTULACA association
- 2 SESUVIUM - ERAGROSTIS association
- 3 PORTULACA - SESUVIUM association
- 4 TOURNEFORTIA association
- 5 CORDIA association
- 6 BARREN AREAS
- 7 WATER

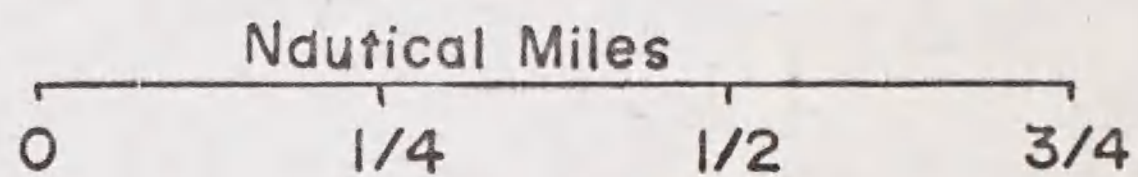
ENDERBURY

Nautical Miles
0 1/4 1/2 3/4



- 1 LEPTURUS - PORTULACA association
- 2 SESUVIUM - ERAGROSTIS association
- 3 PORTULACA - SESUVIUM association
- 4 TOURNEFORTIA association
- 5 CORDIA association
- 6 BARREN AREAS
- 7 WATER

ENDERBURY



C.R. Long
1964

Soil Samples - June-July 1964 Enderbury

- July 11, 1964 Phoenix Island
(5) L199-L203
L199 - 1 1/2-2 in. Lepturus, Portulaca
L200 - 2 Sesuvium 1/2-2 in.
L201 - 3 Lepturus, Portulaca Nesting Sooty Terns
L202 - 4 1/2-2 in.
L203 - 5 1/2 - 2 in. Sida patch - mid north part of island
- July 12, 1964 Phoenix Island
(3) L204-L206
L204 - 1 Algal layer 1/2 in. deep lagoon. Lepturus stand at edge of lagoon (with a narrow strip of Sesuvium at edge between the grass and the bare surface of the lagoon.
L205 - 2 1/2-2 in. windblown soil around slab rocks.
L206 - 3 1/2-2 in. Lepturus South end.
- July 13, 1964 Phoenix Island
(3) L207-L209
L207 - I Sesuvium mat - dry, open area (0.5-2 in. layer), many roots present; soil dark brown.
L208 - II Soil accumulation under coral rock slab. Windblown mineral matter; dried organic (Lepturus, Portulaca) - crab burrows along edge of rock.
L209 - III Bare soil surrounded by Portulaca and Lepturus. Gravel at surface 0.5 in. (0.5-2 in. layer)
- July 15, 1964 Enderbury Island
(1) L210
L210 Eragrostis, Sesuvium 1/2-2 in.
- July 16, 1964 Enderbury Island
(4) L211-L214
L211 - 1 1/2-2 in. Portulaca, Boerhaavia, Lepturus west side of lagoon.
L212 - 2 Portulaca, Boerhaavia gravel top, fine beneath, northwest end.
L213 - 3 top 1/2 in. Cordia grove west end.
L214 - 4 1/2-2 in. Cordia grove west side
- July 17, 1964 Enderbury Island
(2) L215-L216
L215 - 1 South end Eragrostis sp., Sesuvium sp. soil 6 in. deep 1/2-2 in.
L216 - 2 Cement floored storage house - hermit crab accumulation.
- July 18, 1964 McKean Island
(7) L217-L223
L217 - 1 Under Sida, Sesuvium 1/2-2 inches
L218 - 2 1/2-2 in. under dead Sesuvium nest of masked booby
L219 - 3 1/2-2 in. bare lagoon dry on top
L220 - 4 Boerhaavia, Digitaria near beach, 1/2-2 in.
L221 - 5 1/2-1 in. rock area gravel on top south end Boerhaavia, Sesuvium
L222 - 6 1/2-2 inches Digitaria, Portulaca, Boerhaavia
L223 - 7 Sida, near old guano ruins 1/2-2 in. nesting sooty terns

C.R. Long
1964

Enderbury
Summary of June-July Botanical Field Work

Hull Island

July 8, 1964

Collections were made on the west island and along the islets stretching to the northeast. Collection No. 1998 - 2038, C.R.Long. Soil samples and photographs were made.

July 9, 1964

Collections were made on the islets due south and across the lagoon from the ATF camp and proceeded southwest to the west island. The northeast islets were not visited. Collection No. 2039 - 2076, C.R.Long. Soil samples and photographs were made.

Phoenix Island

July 10, 1964

The island was circuited and traversed several times. Collection No. 2077 - 2083. Photographs and soil samples secured.

July 11, 1964

Collection No. 2084 - 2088. Photographs and soil samples taken.

July 12, 1964

Permanent markers were placed. Transects of vegetation carried out. Collection No. 2089, C.R.Long. Assisted with the banding of masked boobies and red-footed boobies.

July 13, 1964

Vegetation information was gathered and permanent markers were placed.

Enderbury Island

July 15, 1964

Collected the west side of the island. Collection No. 1990 - 2010

C.R. Long.

C.R. Long
1964

July 16, 1964

Worked on U.S.S. Takelma in the morning and early afternoon.
Collected and placed permanent markers during the late afternoon, and
early evening on the north end of the island. Collection No. 2011 - 2020.

July 17, 1964

Collected in the west, south and east sides of the island.
Collection No. 2021 - 2024.

McKean Island

July 18, 1964

Vegetation transects were made on north and south ends of
the island. Collection No. 2025 - 2037. Permanent markers were placed.
Photographs were taken. Assisted in banding of masked boobies.

July 19, 1964

Collection No. 2038 - 2048. Collected along the west and north
from the ends of the island. Assisted in the banding of masked boobies.

Baker Island

July 21, 1964

Collections made on the south, east, north and west portions
of the island. Collection No. 2049 -

Howland Island

July 22, 1964

Vegetative transects were made. Collection No. 2170 - 2179.
Permanent markers were placed.

July 23, 1964

Vegetative transects and photographs were made. Permanent
markers were placed.

C.R. Long
1964

Enderbury

Enderbury Island July 15, 1964

- 1 Sida fallax Walp.
- 2 Triumfetta procumbens
- 3 Portulaca lutea Sol.
- 4 Digitaria pacifica Stapf.
- 5 Lepturus repens (Forst.) R.Br.
- 6 Boerhaavia diffusa (Forst.) R.Br.
- 7 Cassytha filiformis L.
- 8 Eragrostis whitneyi Fosberg
- 9 Sesuvium portulacastrum L.
- 10 Ipomoea sp.
- 11 Messerschmidtia argentea (L.f.) Johnston
- 12 Cordia subcordata Lam.
- 13 Fleurya ruderalis (Forst. Gaud.

McKean Island July 18, 1964

- 1 Sida fallax Walp.
- 2 Lepturus repens (Forst.) R.Br.
- 3 Portulaca lutea Sol.
- 4 Boerhaavia diffusa L.
- 5 Digitaria pacifica Stapf.
- 6 Tribulus cistoides L.
- 7 Sesuvium portulacastrum L.

Baker Island July 21, 1964

- | | | | |
|---|---------------------------------------|----|------------------------------------|
| 1 | <u>Triumfetta procumbens</u> | 5 | <u>Boerhaavia diffusa</u> L. |
| 2 | <u>Digitaria pacifica</u> | 6 | <u>Euphorbia hirta</u> L. |
| 3 | <u>Sida fallax</u> Walp. | 7 | <u>Portulaca lutea</u> Sol. |
| 4 | <u>Lepturus repens</u> (Forst.) R.Br. | 8 | <u>Euphorbia prostrata</u> Sit. |
| | | 9 | <u>Mimosa sensitiva</u> |
| | | 10 | <u>Cynodon dactylon</u> (L.) Pers. |

C.R. Long
1964

Enderbury

Addenda to the Report of C. D. Hackman, February - March ATF, 1964.
Plants.

Enderbury Island

February 27, 1964, Sida sp. - Sida fallax Walp. or close. The Sida specimens collected from the Phoenix Islands are partially indistinguishable from Sida cordifolia L. and Sida fallax Walp. A nomenclatorial change or a new taxa may be indicated.

Cordia sp. - probably Cordia subsordata Lam. but possible Cordia sebestena L.
Dodder sp. - Cassytha filiformis L.

February 28, 1964 - "grass is quite small and easily overlooked" -
Eragrostis whitneyi Fosb. var.

Canton Island

March 2, 1964 - Scaevola taccada or Scaevola frutescens (Mill.) Krause for Scaevola sp. The former name is the oldest which may be applied to material commonly called frutescens by most authors. However, the Scaevola in the Phoenix and Line Islands varies from the Scaevola found to the north and new taxa are indicated with the proper nomenclatorial changes.-" several clumps of the species of grass we had discovered near the lagoon on Enderbury"- Eragrostis whitneyi Fosb. var. There are two varieties of this species.

Jarvis Island

March 14, 1964

Sida sp.-Sida fallax Walp. - see above February 27 note

Boerhaavia sp. -B. diffusa L. var. tetrandra Heimerl. - but the status of these color variations also noted on Hull Islnd indicate new taxa.

Portulaca sp. - Portulaca lutea Sol.

March 15, 1964

"The small bunchgrass-" - Eragrostis whitneyi Fosb. var.

"ragweed plant-" - Chenopodium ambrosioides L.

Illustrations: -7. Cordia subcordata Lam.; 6. Portulaca lutea Sol.;
5. Lepturus repens (Forst.) R.Br.; 4. Digitaria pacifica Stapf.; 3. Sida fallax Walp.; 2. Tribulus cistoides L.; 10. Euphorbia prostrata L.; 11. Cenchrus echinatus L.; 12. Cynodon dactylon (L.) Pers.; 13. Setaria verticellata (L.) Beauv.; 14. Triumfetta procumbens L.; 15. Sesuvium portulacastrum L.;
16. Messerschmidtia argentea (L.f.) Johnston; 17. Cassytha filiformis L.;
18. Ipomoea indica (Burm. f.) Merr.; 19. Eragrostis whitneyi Fosb. var.;
21. Chenopodium ambrosioides L.; 22. Eragrostis whitneyi Fosb. var.; 24. Suriana maritima L.; 25. Heliotropium anomalum H. and A.; 26. Scaevola taccada
27. Acanthaceae (we are having difficulty keying this to genus and species level- it is not grown in Hawaii and may have been introduced from the southwest Pacific area); 28. Polypodium scolopendrim Burm. f.

C. R. Long
Research Curator